ARMY

PROPOSAL SUBMITTAL INSTRUCTIONS

The United States Army Research Office (ARO, reporting to the Army Research Laboratory ARL) manages the Army's Small Business Technology Transfer (STTR) Program. The following pages list topics that have been approved for the fiscal year 2002 STTR program. Proposals addressing these areas will be accepted for consideration if they are received no later than the closing date and hour of this solicitation. Such proposals may be submitted to ARO at either its physical address or its postal address:

Physical Address for Private Delivery Services
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The Army anticipates funding sufficient to award one or two STTR Phase I contracts to small businesses with their partner research organizations in each topic area. Awards will be made on the basis of technical evaluations using the criteria contained in the solicitation, within the bounds of STTR funds available to the Army. If no proposals within a given area merit support relative to those in other areas, the Army will not award any contracts for that topic.

Phase I contracts are limited to a maximum of $100,000 over a period not to exceed six months.

Based upon progress achieved under a Phase I contract, a firm may be invited to propose Phase II. Any Phase II contracts following on Phase I proposals submitted under this solicitation will be limited to a maximum of $500,000 over a period of two years. Contract structure for the Phase II contract is at the discretion of the Army's Contracting Officer after negotiations with the small business.

Please Note!

The Army requires proposers to submit the Proposal Cover Pages and Company Commercialization Report electronically. The Army will also accept the full Technical Proposal and the Cost Proposal (Reference A of this solicitation) via the Internet on a voluntary basis. Electronic submission of the Cover Pages and Company Commercialization Report (mandatory); and, Technical Proposal, and Cost Proposal (voluntary), can be executed at http://www.dodsbir.net/submission), which will lead you through the preparation of these forms and the upload of the Technical Proposal. The Army strongly encourages electronic submission of the entire proposal as practice for future Solicitations where submission will be fully electronic. Refer to section 3.4n at the front of this solicitation for detailed instructions on the Company Commercialization Report. You must print out the Proposal Cover Sheet, Company Commercialization Report, and Cost Proposal (if submitted electronically) directly from the Website, sign them, and submit them with the hard copies (1 original and 4 copies) of your proposal.

Please note that a proposal is not considered accepted until the Army receives 1 original and 4 copies of the entire packet (signed Cover Pages, signed Company Commercialization Report, signed Cost Proposal, and Technical Proposal) in hard copy, by the Solicitation closing date and hour, even if the entire proposal was submitted electronically.

Improper handling of these forms may result in the proposal being substantially delayed. Information provided on the Company Commercialization Report will have a direct impact on the evaluation of the proposal.

ARMY FY02 STTR TITLE INDEX

ARMY STTR 2002 TOPIC DESCRIPTIONS

ARMY02-T001 TITLE: Leader Self-Development Support Program

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Leader Instruction Division of Center for Army Leadership

OBJECTIVE: To design, develop and evaluate a leader self-development support program that recognizes the importance of self-insight and incorporates the cognitive and motivational components underlying the process of leader self-awareness.

DESCRIPTION: Army doctrine explicates a reliance on three forms of leader development: institutional learning, operational experience, and self-development. Currently, the support for self-development of our leaders is not sufficient. This creates a requirement for a program that can help leaders assess their current capabilities realistically and help them improve leader capabilities – especially in non-tactical/technical areas such as interpersonal skills, emotional intelligence and social competence.

Most human resource programs assume the relation between self-insight and goal-setting, individual performance and interpersonal effectiveness. These programs use self-assessment, attitude surveys, performance feedback, developmental planning and such as part of leader development. However, the cognitive processes underlying this development have not been delineated. Additionally, the techniques used to enhance leader development through self-awareness have not been evaluated sufficiently. Socio-cognitive research highlights the existence of human tendencies such as ego defense mechanisms, self-affirmation and biased processing of self-related information that present significant barriers to accurate self-awareness.

An understanding of how these processes impact self-development of leader competencies and how these processes can be countered is necessary in order to maximize the insight leaders could gain about themselves from various developmental interventions. New capabilities cannot be developed efficiently until one knows the realistic level of capability they currently possess. Finally, a consideration of the research on the motivation for one to seek, accept, and use developmental feedback tools should be demonstrated in the development and design of a support program that facilitates leader growth.

PHASE I: Investigate the effectiveness of various insight-induction techniques used for leader development. Determine the appropriateness or feasibility of adapting these techniques for use by the Army with a consideration of cognitive and motivational theories and guidelines. Design a prototype program.

PHASE II: Develop a leader self-development support program that by-passes defense mechanisms to obtain self-insight and leverages self-knowledge for improving leader competencies. Evaluate the program for application to Army personnel.

PHASE III DUAL USE APPLICATIONS: The commercialization of this program is highly feasible. Any corporation or organization interested in developing their own leaders would find this program invaluable, as it would provide an excellent tool for human resource and training offices. This program provides the added appeal of potentially reducing the cost of leader development interventions for which corporations typically spend a significant amount of time and money.

REFERENCES:

1. Ashford, S.J. (1989). Self-assessments in organizations: A literature review and integrative model. Research in Organizational Behavior, 11, 133-174.

2. Army Leadership. FM 22-100, Washington, DC: Headquarters, Department of the Army.

3. London, Manuel (1995). Self and Interpersonal Insight: How People Gain Understanding of Themselves and Others in Organizations. New York: Oxford University Press.

KEYWORDS: Self-awareness, Self-development, leadership, leader development, self-insight

ARMY02-T002 TITLE: Terahertz (THz) - Frequency Differential-Absorption Spectrometer for Remote Biological Agent Detection

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To design, build and field-test a THz-frequency differential-absorption spectrometer that can be used for the remote detection of biological warfare agents. The envisioned sensor should be developed such that it is deployable both as a stationary perimeter defense system and as an outward-looking remote scanning system.

DESCRIPTION: In the past decade, there has been a proliferation of chemical and biological (CB) agents as instruments of warfare and terrorism. CB agents certainly present a serious threat both to the civilian and military sectors and an adequate defense against these weapons will require rapid detection and identification of both known and unknown agents. Clearly, the most serious threat of CB agents is the potential harm they present to the short and long-term health of the victims. However, the actual or perceived threat of such warfare agents can impact the operational capability of a military force in the field even when conventional counter-measures (i.e., protective equipment and clothing) are successfully employed. For these fundamental reasons, the development of reliable approaches for the detection and identification of CB agents in the field of operation is imperative. The CB warfare threat is also of strategic importance in relation to the Army's Future Combat Systems (FCS) vision [1] as the issue of survivability will be impacted by the FCS's ability to counter CB threats. Therefore, it is not surprising that the issue of establishing an automatic detection, alert, avoidance and protection system for areas contaminated by weapons of mass destruction has always been a component of the FCS concept. While much work remains to improve the overall capability of chemical sensing in the field (e.g., sensitivity, size, weight, etc.), methods for point-detection are available for all known chemical agents. On the other hand, the present capability for point-detection of biological (bio) agents is limited to the identification of only four species [1]. This limitation in point-detection and the limitations of an effective standoff (i.e., remote) capability is of the highest priority to the Joint Future Operation Capability, as well as to the Joint Service Leader for Contamination Avoidance and most importantly to the DoD. When these general problems are combined with the need to realize a compact (i.e., very small size and weight) total CB systems package for the FCS concept, it is obvious that new approaches will be necessary.

Recent scientific work in biological spectroscopy at very high frequencies has suggested a novel avenue for a terahertz (THz) electronic approach to bio-warfare agent detection and identification [2]. These studies support previous theoretical analysis that predicted unique resonant-phonon absorption features within the basic components (i.e., DNA) of biological materials [3]. Furthermore, very recent estimates of sensitivity and discrimination for THz-frequency differential-absorption spectrometers offer the promise of achieving a remote sensing capability for biological spore material [4, 5]. The currently proposed effort would integrate existing solid-state electronic components towards the realization and demonstration of a remote sensing system that can be effectively utilized as an early warning system against biological agent attack. The system should be designed for functionality as a perimeter defense system (i.e., fixed and stationary) and as an outward-looking system with a capability for remotely scanning for airborne biological agent clouds. The expected system should possess a capability for effective operation (e.g., high frequency resolution and broadly tunable) within the THz frequency band. The system should leverage fully-integratable semiconductor-based components to enable the realization of a compact and cost-effective sensing system. The system should be field-tested to demonstrate the sensitivity limits and discrimination capability. Finally, the system should be developed such that it is amenable to battlefield deployment type scenarios.

PHASE I: Conduct a comprehensive analysis and design phase for a semiconductor-based THz frequency differential-absorption spectroscopic system. This work should include the identification and acquisition of the base source and detector components for construction of the sensing system. This work should also include a laboratory-based experimental study of target agents and expected interferent agents for the purpose of developing a database of the required THz-frequency spectral signatures. An investment in spectral signature modeling may also be expected for enhancing the interpretation of spectral results used in the future. Enhancing algorithms, such as neural network modeling, might also be identified and developed to deal with spectral fluctuations that arise due to environmental influences on the target biological agent.

PHASE II: Develop and demonstrate a prototype THz frequency differential-absorption spectroscopic system for the remote sensing of aerosol simulant agents such as Bacillus subtillus. Plan, coordinate and execute field testing of the prototype system that test the sensitivity limits and discrimination capability.

PHASE III DUAL USE COMMERCIALIZATION: The technologies developed under this topic will provide a foundation for a new class of remote sensors and further a technology that has potential towards medical applications for the microscopic interrogation of biological characteristics and chemical function. This spectroscopic technique also has potential towards the characterization of other materials of interest such as electronic materials and explosives.

REFERENCES:

1. D. Woolard, "Terahertz Electronics Research for Defense: Novel Technology and Science," in the proceedings to the 2000 Space THz Conference, U. of Michigan (2000).

2. D. Woolard, et. al., "Terahertz Electronics for Chemical and Biological Warfare Agent Detection," in the proceedings to the 1999 IMS, June 13-19, Anaheim, CA, pp. 668-672 (1999).

3. L. L. Van Zandt and V. K. Saxena, "Vibrational Local Modes in DNA Polymer," J. Biomolecular Structure & Dynamics, 11, pp. 1149-1159 (1994).

4. T. Globus, et. al., "Application of Neural Network Analysis to Submillimeter-wave Vibrational Spectroscopy of DNA Macromolecules," in the proceedings to the 2001 ISSSR, June 12-15, Quebec City, Canada (2001).

5. D. Woolard, et. al., "Sensitivity Limits & Discrimination Capability of THz Transmission Spectroscopy as a Technique for Biological Agent Detection," in the proceedings to the 5th Joint Conference on Standoff Detection for Chemical and Biological Defense, Williamsburg, VA, 24-28 Sept., 2001.

KEYWORDS: Terahertz frequency sensors, biological agent detection, remote sensing

ARMY02-T003 TITLE: Software Tools for High Performance Computing

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The purpose of this project is to develop software tools that enable DoD researchers to use parallel computers and that make software portable across different parallel architectures.

DESCRIPTION: As the Army requires larger, more detailed numerical simulations for scientific and engineering computations, it becomes necessary to perform these computations on high performance parallel computer architectures. Currently, it requires a significant amount of detailed hand coding of message passing primitives [1] to port a computer code which was originally written for a serial or vector computer to a parallel machine or network of machines. Also, once a code has been ported to one parallel architecture, it may require additional work to port it to other architectures even when both machines have similarities. New approaches are needed to reduce the effort required to use parallel machines and to increase the portability of computer software between parallel machines.

University research has generated a number of approaches to the problems of generating portable parallel code. For example, Reference [3] describes software tools to support the solution of partial differential equations using parallel adaptive finite element methods. This software uses a hierarchical design to manage mesh and solution data accounting for the many data structures used with adaptive computation and a variety of computer architectures. Other researchers [2] have developed multi-constraint graph partitioners which permit multi-phase and multi-physics computations to be load balanced among the processors and for communication between subdomains and domains with different physics to be minimized. These algorithms have been added to the popular Metis package. Elsewhere, there has been a long term effort in the research on intelligent scientific visualization software. One result [4] has been the development of algorithms to extract important features from unsteady CFD solutions and display them in an understandable manner. These are examples of basic research which is ready to be transitioned to software which should be made generally available.

For this topic, university researchers should team with commercial software developers to develop software tools for parallel computation. These could include environments for parallel mesh generation, load balancing, adaptive refinement and visualization. It is expected that these tools could be used to port existing serial codes to multiple parallel architectures.

PHASE I: Determine what kinds of tools are needed to automate the porting of existing software to different parallel architectures. Determine what research is available to generate tools to aid this process and what tools are available for support activities such as parallel grid generation and visualization. Develop a framework for a computing environment for automating parallel computation.

PHASE II: Use the information developed in Phase I to develop a library of software tools which can be used to support parallel computation. This can include, but is not limited to, tools for the porting of code, grid generation, load balancing, adaptive refinement and visualization. These tools should be tested on multiple architectures and existing software of interest to DoD.

PHASE III DUAL USE COMMERCIALIZATION: The development of vectorizing compilers led to the widespread acceptance of vector processors for both military and civilian applications. Better software tools are required before parallel architectures become the general purpose computers of tomorrow.

REFERENCES:

1. M. Snir and W. Gropp, MPI: The Complete Reference, (2-volume set), MIT Press, 1998.

2. K. Schloegel,G. Karypis and V. Kumar, "Parallel Static and Dynamic Multi-Constraint Graph Partitioning", Concurrency: Practice & Experience, 2001.

3. J.D. Teresco, M.W. Beall, J.E. Flaherty and M.S. Shephard, "A Hierarchical Partition Model for Adaptive Finite Element Computations", Comp. Meth. Appl. Mech. Engng., 184(2-4):269-285, 2000.

4. R. Haines and D. Kenwright, "On the Velocity Gradient Tensor and Fluid Feature Extraction", AIAA Computational Fluid Dynamics Conference, AIAA Paper 993288, Norfolk, VA, June, 1999.

KEYWORDS: Parallel Computing, Software Tools, Automatic Parallelization, Load Balancing, Visualization

ARMY02-T004 TITLE: Analysis and Characterization of Pattern Classifiers

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Improved Automated Target Acquisition and Tracking.

DESCRIPTION: The mainstay of Automatic Target Recognition (ATR) systems is statistical pattern recognition, usually based on Bayesian methods. One weakness of Bayesian classifiers is that the method does not provide a reason for its decisions. That is, a classifier cannot distinguish between the consistent but low probability data, and inconsistent data.

As a trivial example, consider a Bayes decision making system which receives informa-tion from two independent classifiers, both of which make decisions between the mutually exclusive events, “tank”, “bus”, and “other”. The Bayes decision maker simply calculates the product of the tank and bus decisions from the two classifiers (operating under the independence assumption. Imaging two scenarios: in once case, classifier 1 reports that the probability of TANK is very high, BUS is low, and OTHER is low, but classifier 2 concludes exactly the reverse of TANK and BUS. In a second scenario, both classifiers agree that both TANK and BUS are unlikely, and the best decision is OTHER. It is easy to construct a numerical example where the Bayesian decision makes arrives at the same conclusion (it must be OTHER) for both scenarios. There are straightforward ways to approach this example, and it is given only to provide a simple demonstration of the much more general problem.

Recent results in several areas have suggested that there are ways to improve the performance of Bayesian pattern classifiers by incorporating concepts from evidence theory and/or from the weights of support vector machines.

PHASE I: Develop methods for incorporating evidence theory, such as Dempster-Shafer theory, into pattern classifier theory, and demonstrate such methods on realistic ATR data. This work may include new methods for design of classifiers.

PHASE II: Develop a “benchtop” prototype system, including hardware and software which will observe a scene and, when provided with supervised target cueing data, auto-matically develop a pattern recognition algorithm for identifying that target in those sur-roundings. This system may include multispectral imaging capability.

PHASE III DUAL USE COMMERCIALIZATION: Develop a prototype missile seeker system, including an off-line training component, which may receive training data from a UAV or similar source, and which will use that information to program an on-board mis-sile target acquisition system.

Multiple civilian/commercial uses of this technology clearly exist. In addition to classification and tracking of military targets on the ground, in the air and in the water, pattern recognition systems find potential application in airport x-ray, intruder detection, even identifying possible intrusions into data networks. Additional uses include detection of chemical/biological weapons by-products, agricultural monitoring, and industrial inspec-tion and quality control. Any general theory which improves the quality of pattern recog-nition system performance is useful in all these applications.

REFERENCES:

1. C. Burges, “A Tutorial on Support Vector Machines for Pattern Recognition”, Data Mining and Knowledge Discovery, Vol. 2, Number 2, Kluwer, 1998.

2. L. A. Alexandre, A.C. Campilho, M. Kamel, “Combining independent and unbiased classifiers using weighted average,” Proceedings of IEEE 15th International Confer-ence on Pattern Recognition, Vol. 2, pp. 495-498, 2000.

3. Hee-Joong Kang, Seong-Whan Lee, “Combining classifiers based on minimization of a Bayes error rate,” Proceedings of the Fifth International Conference on Document Analysis and Recognition, pp. 398-401, 1999

4. A.S. Atukorale, P.N. Suganthan, “Combining classifiers based on confidence values,” Proceedings of the Fifth International Conference on Document Analysis and Recogni-tion, pp. 37-40, 1999.

5. L.I. Kuncheva, C.J. Whitaker, C.A. Shipp, R.P.W. Duin, “Is independence good for combining classifiers?,” Proceedings of the 15th International Conference on Pattern Recognition, Vol. 2, pp. 168-171, 2000.

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7. N.R. Pal, S. Ghosh, “Some classification algorithms integrating Dempster-Shafer the-ory of evidence with the rank nearest neighbor rules,” IEEE Transactions on Systems, Man and Cybernetics, Part A, Vol. 31, No 1, January 2001

8. Xinhua Zhang, Liangji Lin, Jicheng Wang, “A decision fusion approach for target clas-sification,” IEEE International Conference on Systems, Man and Cybernetics, Vol. 1, pp. 667-671, 1996

KEYWORDS: ATR, multispectral signature, pattern classification, evidence theory, support vector machines

ARMY02-T005 TITLE: Micromachined, Three-Dimensionally Integrated RF or RF-Optoelectronic Circuit Components

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: CECOM RDEC I2WD

OBJECTIVE: Design a new RF or RF-Optoelectronic component that exploits the low cost, high density capabilities of three-dimensional micromachined circuit integration and packaging.

DESCRIPTION: Recent advances in micromachined silicon techniques demonstrate the capability for 3 dimensionally integrated RF circuits with extremely low loss interconnects and a high degree of isolation, leading to circuits which are unprecedentedly dense. The resulting IC’s are self packaged, without the requirement for additional packaging and without spurious electromagnetic effects on the circuit due to the package. This technology provides the potential for very low cost, very inexpensive, small, compact RF components. It further provides the opportunity to integrate chips of other materials and device systems, such as MEMS, GaAs, InP, widebandgap devices, ferroelectric devices, or opto-electronic, into the micromachined silicon architecture. This topic encourages new and novel architectural approaches to RF or RF-Optoelectronic circuits using 3D micromachining integration. Proposed components operating above the RF frequency of 10 Ghz and which exploit the unique capabilities of this integration technology are sought under this topic.

PHASE I: Demonstrate the feasibility of the component by simulation and laboratory demonstrations of the critical integration steps.

PHASE II: Develop a prototype component capable of testing under realistic field conditions.

PHASE III DUAL USE APPLICATIONS: Such small, light weight, low cost RF or RF-Optoelectronic components will have major potential applications in military communications, radar, and missile guidance systems. They will have major potential commercial applications in such systems as optical communications, LMDS communications, and satellite communications.

REFERENCES:

L.P.B. Katehi, J.F. Harvey, and K.J. Herrick, “3-D Integration of RF Circuits Using Si Micromachining, in IEEE Microwave Magazine 2, p. 30 (March 2001), and the references therein.

KEYWORDS: micromachined integration, 3-D integration, RF integration

ARMY02-T006 TITLE: Modeling the Warrior as a Cognitive System

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To identify and mathematically formalize the impact, both positively and negatively, of new technologies on a warfighter's cognitive readiness and physical performance.

DESCRIPTION: The military has become increasingly aware of the significance of large-scale data systems and the importance of new generations of technology. In parallel with these developments must be the advancement of human systems to determine the response of the warrior in a hostile environment to such new technologies and the behavior of the warfighter as a complex system. In particular it must be determined whether the information received by the warrior is in a form that he/she can perceive, understand and act upon. This circumstance comes under the headings of situational awareness (SA) and cognitive readiness (CR). SA and CR are defined as the warrior's ability to quickly perceive and then discriminate between facets of the tactile environment, to accurately assess and reassess the where, when and why of that environment, and to know and understand the nature of the tactical situation in order to extrapolate near term courses of action based on this understanding.

The lack of a data-based theory of cognition and response has to do with the modeling of phenomena formed through the multiple interactions of structured subsystems to perform particular tasks. In general, the fundamental elements of which the cognitive and response systems are composed are themselves complex rather than simple; the interactions among subsystems, as well as within subsystems, are generically not linear and therefore do not lend themselves to traditional stimulus response analysis, and finally, the properties of subsystems observed in the laboratory almost never scale to field conditions. The recent results obtained in mathematical disciplines of nonlinear dynamics systems theory, the processing of stochastic time series with memory, and universal scaling, may allow us to do today what could not be done as little as ten years ago.

The quantitative SA/CR model should include the design and implementation of new methodologies for modeling long-term memory in statistical environments in order to extract nonlinear dynamical trends from complex data sets. This model should be adaptive and contain active control system elements to maintain stability.

PHASE I: Develop the formalism for a quantitative SA/CR model of the soldier as a complex cognitive system that is adaptive and scalable and able to model and/or simulate SA and CR. The emphasis of the formalism should be on the cognitive response of soldiers under conditions of stress and constructed from a variety of data bases that are of value for the military.

PHASE II: Develop and implement scalable, multi-processing algorithms for the SA/CR model. Verify the model against data bases that were not used in the determination of the quantitative metrics concerning the level of soldier readiness.

PHASE III DUAL USE APPLICATIONS: Quantitative measures of a person's ability to perform under stress will not only provide the military with the capability of forecasting the reliability of realistic battlefield senarios, but may also play a role in our understanding of the psychology of terrorists and teenagers that kill other teenagers.

REFERENCES:

1. B.J. West, "Fractal Probability Measures of Learning", Methods 24, 395-402 (2001).

2. B.J. West, Physiology, Promiscuity and Prophecy at the Millennium: A Tale of Tails, World Scientific, New Jersey (1999).

KEYWORDS: Human performance, metrics, cognitive modeling, situational awareness

ARMY02-T007 TITLE: <u>Second Generation Biosensor</u>

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Current biosensors tend to rely on single or a few DNA or antibody probes. While these types of detection are effective at distinguishing natural pathogens vs natural non-pathogens, they are unlikely to be effective against bioengineered pathogens. In order to design a biosensor that can not be overcome by genetic engineering it is necessary to completely understand the proteins required for virulence. It is necessary to understand at an amino acid level, which residues are required for virulence, and which amino acid substitutions can be made without losing virulence. The objective for this STTR is to use saturation mutagenesis to completely define the critical domains of a virulence gene of a key pathogen, and to use this information to design a detection system that will detect all possible virulent forms of the pathogen.

DESCRIPTION: The recent events in the U.S. have validated the fear that terrorists will use biowarfare agents in the homeland or on U.S. troops abroad. Timely administration of countermeasures and use of protective gear depends on rapid, highly accurate detection. There are two technological barriers to effective biowarfare agent detection. 1) A number of relevant pathogens have not been studied in enough depth to know which amino acid residues of the virulence proteins are critical for function. 2) Current biowarfare agent sensors rely on too few antibody or nucleic acid probes, and thus are likely to miss detection of bioengineered pathogens. The objective of this STTR is to experimentally develop a bioinformatic database that saturates the virulence gene of an important biowarfare threat agent, and to use this information to design and build a prototype detection system that will detect every virulent mutant of that pathogen, but will give no false alarms. This detection system will have hundreds of probes, so that there will be no false positives and no false negatives. The system will be rugged, light-weight, and low-cost. A side benefit of this type of detection is that it will be obvious to investigators whether the particular pathogen that is encountered is man-made or not, and where the strain originated.

PHASE I: The investigators will, in consultation with a DoD advisory board, have selected a pathogen for which appropriate animal models are available. Mutagenesis of the virulence gene(s) will be done using molecular biology, biochemistry, and bioinformatics. Critical regions of the protein will be identified, and this region or regions will begin saturation mutagenesis to identify all possible virulent mutants. All mutants will be tested for virulence using 96 well plates containing living cells, or other high-throughput assay system. And the end of phase I the investigators will demonstrate that they have a system that will allow them to completely understand the virulence protein or proteins in this particular pathogen, including what residues are required for virulence, and what mutations in these residues still enable the protein to retain function, by the end of phase II. The investigators will also demonstrate they that have, or have initiated collaborations with individuals or institutions that have, sufficient scientific and physical resources to develop a prototype in phase II.

PHASE II: The investigators will complete the saturation mutagenesis of the virulence gene. All virulent variations of the natural virulence protein will have been identified. The investigators will design and produce an inexpensive, lightweight prototype device that can be worn by individual warfighters. This device may be disposable, or may have replenishable reagents, however the device should function at least two weeks without human intervention. The device will sample air and will test the organisms in the air frequently (every minute or so). The device will be set up to automatically alarm (using vibrations or another non-audible method, as well as a visual signal) and record the incident if virulent pathogens are detected. The investigators will demonstrate the ability of the device to detect the virulent pathogen under field conditions, including temperature and humidity extremes, and in the presence of other environmental bacteria and viruses, as well as dust, dirt, etc.

PHASE III: The company will produce inexpensive devices for this particular pathogen as needed by the Armed Forces and U.S. civilians. It is anticipated that these devices will be used in buildings and other public gathering places that are vulnerable to terrorist attack, as well as in hospitals and nursing homes where susceptibility to pathogens is high. It is anticipated that this successful demonstration of this type of second generation biosensor will attract private investors who will repeat this type of comprehensive approach on other pathogens. Gathering of this type of data for other biowarfare agent pathogens and generation of the appropriate probes, will enable the company to market third generation sensors that could detect most biowarfare agents. This approach would then be repeated for the remaining pathogens, so that the fourth generation device would detect all pathogens that could be used as biowarfare agents.

KEYWORDS: Bioinformatics, functional genomics, microarrays, chips, pathogens, BW.

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Wieczorek DJ, Feiss M. 2000. Defining cosQ, the site required for termination of bacteriophage lambda DNA packaging. Genetics, 158(2):495-506.

Wrobel JA, Chao SF, Conrad MJ, Merker JD, Swanstrom R, Pielak GJ, Hutchison CA 3rd. 1998. A genetic approach for identifying critical residues in the fingers and palm subdomains of HIV-1 reverse transcriptase. Proc Natl Acad Sci U S A, 95(2):638-45.

Wrobel JA, Conrad MJ, Bloedon E, Swanstrom R, Hutchison CA 3rd. 2000. Analysis of HIV type 1 reverse transcriptase: comparing sequences of viral isolates with mutational data. AIDS Res Hum Retroviruses, 16(18):2049-54.

ARMY02-T008 TITLE: Compact Intermediate-Temperature Fuel Cells

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: Project Manager – Soldier Systems

OBJECTIVE: Develop a mechanically robust, high-conductivity, proton-conducting inorganic membrane that does not require water maintenance for proton transport. Using such a membrane, fabricate membrane-electrode assemblies and assemble into a 10-50 W, intermediate-temperature air/hydrocarbon fuel cell (T < 400 C).

DESCRIPTION: The Army has need for high-energy, lightweight power sources. Hydrogen-air and direct-methanol polymer electrolyte membrane fuel cells (PEM FCs) are candidates to fill these needs, but the polymer electrolyte must be hydrated for proton conductivity, which adds the complexity of a water-management system and limits the operation temperature. Certain classes of inorganic materials are known proton conductors that, if successfully incorporated as the electrolyte in a fuel cell, offer the possibility of eliminating the weight, volume, and system complexity associated with a water-management system. In addition, the cell could operate at elevated temperature (in comparison to PEM FCs) which would enable the direct electrochemical oxidation of high-energy density, liquid hydrocarbon fuel (e.g., methanol, propane, or butane [MeOH, C3, or C4]).

PHASE I: Identify and characterize inorganic proton-conducting materials that may be fabricated into membrane form and are competitive at T < 400 C with the resistivity of state-of-art PEMs (~ 0.1 ohm cm2). Determine the protonic conductivity, gas permeability, and chemical, electrochemical, and mechanical stability of candidate membranes at operating temperatures. Demonstrate that viable anode and cathode electrodes can be fabricated on the membranes. Identify and analyze critical issues/concerns that must be addressed for application of these membranes in a direct hydrocarbon FC.

PHASE II: Using membranes from the Phase I effort and addressing the critical issues identified therein, assemble and evaluate a 10-50 W air/(MeOH, C3, or C4) intermediate-temperature FC (T < 400 C). The FC power system should be compact (> 1 kW/L and >1 kW/kg) and well insulated thermally.
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PHASE III DUAL USE COMMERCIALIZATION: Developments in fuel cell power sources will have immediate impact on a wide range of commercial power sources from computer power to emergency medical power supplies to recreational power uses.

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KEYWORDS: Fuel cell, proton conductor, membrane-electrode assembly, soldier power

ARMY02-T009 TITLE: <u>Fluorescent Coated Filters for Detection of Biological Warfare Agents in Water</u>

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To develop filters coated with fluorescent bio-mimetic polymers for the concentration and detection of biological warfare agents in water. The filters will be integrated into a flow system that will include a fluorescent detector for visualization.

DESCRIPTION: This solicitation focuses on the development of a sensor for fluorescent detection of BWA micro-organisms in water in the instance of a biological attack or general contamination. ELISA assays using coated plates and fluorescent, luminescent or colorimetric visualization, have been developed for detection of BWAs in aqueous samples, however, they require multiple reagent addition, incubation and wash steps, and hence are not appropriate for a quick simple test that can be performed by unskilled personnel or for continuous monitoring. In addition, the environmental aqueous samples (i.e. from rivers or lakes) need to be pre-concentrated before detection so they fall into the detection range of ELISA assays. Filters, coated with sensing polymers designed to bind BWAs, could simultaneously concentrate the samples, and bind and detect the targets. The bi-layer or multi-layer surfactant structure of the polymer coating provides a suitable bio-mimetic environment for the interaction of ligands (i.e. antibodies) and BWAs. Binding of the analyte leads to fluorescence generation, providing a sensitive signal. Such filters would be integrated into flow systems with suitable optics for fluorescence detection.

PHASE I: Development of a model fluorescent polymerized bi-layer or multi-layer filter coating for the detection of one model BWA target in an aqueous sample. This would include developing standardized methods for coating preparation and deposition on filters, testing of multiple coating and filter types, and detection of the model target.

PHASE II: Using the model methods developed in Phase I prepare multiple coated filters for the detection of BWA micro-organisms in aqueous samples. Test the filters against each target, against target mixtures and against likely environmental contaminants. Determine optimal testing conditions (flow rate, pressure tolerance, total volume filtered). Characterize detection limits, response time, reproducibility, and signal variation with variation in target mixtures. Develop a flow system that incorporates the filters and provides fluorescence detector.

PHASE III DUAL-USE COMMERCIALIZATION: The proposed coated fluorescent polymer filters could be used for more general environmental testing or monitoring of micro-organisms in water and air. Phase III includes modification/miniaturization of the flow system and detector instrumentation to be portable. The sensing coatings could also be adapted for detection of chemical warfare agents by modification of the ligand. The coated filters could also be adapted for concentrating and detecting airborne targets. Homeland defense and military applications include medical diagnostics of pathogens and disease as well as non-medical contamination avoidance sensors for biological warfare agents.

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KEYWORDS: Biological warfare agents, filter concentration, fluorescent sensing, polymer coatings, biosensors

ARMY02-T010 TITLE: Magnetic Resonance Force Microscopy

TECHNOLOGY AREAS: Chemical/Bio Defense, Electronics

OBJECTIVE: Design, construct and operate a magnetic resonance force microscope (MRFM) capable of in-situ detection of individual magnetic moments (single electron or nuclear spins), and three-dimensional mapping of their position with sub-angstrom spatial resolution.

DESCRIPTION: Magnetic resonance force microscopy (1) represents a promising new technology for direct nondestructive imaging of 3D atomic structure in individual molecules and nanostructures. The technique extends the capability of magnetic resonance imaging by combining it with the high sensitivity and spatial resolution achieved in scanning probe microscopy. The result is a technique with the potential for providing in-situ detection of individual magnetic moments (single electron or nuclear spins), and three-dimensional mapping of their position with sub-angstrom spatial resolution. Development of this technology would be of broad utility to future development of advanced materials, nanoelectronics and biotechnology. The goal of this program is to formulate an integrated system design for the construction of a commercial magnetic resonance force microscope that has sufficient sensitivity to detect a single electron spin. The emphasis is on exploring both hardware and software innovations that will significantly advance the technology with respect to the current state of the art. Proposals should include the construction and demonstration of a prototype system. Approaches that offer the prospect of eventually providing single nuclear spin detection will be given highest priority.

PHASE I: Investigate and demonstrate the feasibility of developing a magnetic resonance force microscope with sufficient sensitivity to detect a single electron spin.

PHASE II: Implement the innovation, which shall include the design and testing of prototype systems. Extend the research to determine whether single nuclear spin detection is feasible. Explore major cost and reliability issues associated with the technology in the context of commercial viability.

PHASE III DUAL USE APPLICATIONS: Magnetic resonance force microscopy offers the capability of mapping the composition and crystal structure of a material at angstrom spatial resolutions. This capability has broad commercial and military utility including: advanced semiconductor-device research (e.g. individual impurity and defect characterization), single-molecule analytical chemistry, infectious disease research, and new solid state physics research (e. g. investigations of electron spin coupling mechanisms and quantum computational physics). This research is intended to introduce a new analytical instrument that affords single atom detection and resolution.

REFERENCE: (1) J.A. Sidles, J.L. Garbini , K.J. Bruland, D. Rugar, O. Zuger, S. Hoen and C.S. Yannoni, Magnetic Resonance Force Microscopy, Reviews of Modern Physics, 67 (1), pp. 249-265, 1995.

KEYWORDS: Magnetic resonance force microscopy, atomic imaging

ARMY02-T011 TITLE: Predictive Injury Model for Soldier Behind-Armor Trauma

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop and demonstrate a robust and accurate computational model for predicting the behind-armor injuries in the human thorax due to blunt impact and designing future body armor systems; the model should include both general soft tissue and primary internal organ/system predictive injury capabilities.

DESCRIPTION: Historical efforts to develop advanced body armors have focused almost exclusively on preventing penetration in order to minimize injury. Although materials with greatly increased resistance to penetration have been successfully developed, the ability to predict physiological behind-armor injury due to specific impact threats does not exist. Blunt trauma remains a significant problem for soldier protection, particularly with respect to the cardiovascular and respiratory systems; in some cases, blunt trauma has even been shown to be amplified by the body armor system.

The general trauma potential of specified threats has been assessed via the use of various gelatins and clays (i.e., DOJ standards) and surrogate thorax devices have been developed (Bir) to simulate limited human cadaver response; however, these efforts have focused solely on the bulk response of the thorax to impact loads. The few models that have been developed are based exclusively on quasi-static biological tissue properties (e.g., Wang). More importantly, no effort has established the capability to predict injury criteria for human physiological materials, organs or systems. Recent conflicts have shown soft tissue wounds to account for forty-four percent of all wounded in action casualties, and objective force operational scenarios have developed even greater interest in predicting behind-armor injuries. Advances in high-strain-rate characterization of soft and brittle materials

(Chen) have recently demonstrated the potential for a much more accurate characterization of biological tissue materials and, thereby, the possibility for a much more robust understanding of the physiological response to blunt trauma.

What is expected from a successful effort is the accurate characterization of biological tissue materials under blunt impact loading conditions and the incorporation of these results into a robust predictive model capable of providing virtual damage assessments for a wide variety of protective solutions and threat scenarios. The model is expected to be able to predict both general soft tissue damage and primary organ/system injuries or failures, and thereby serve as a robust tool for the design of body armor. It is anticipated that this effort will leverage extensively from previous research in the areas of: stress and shock wave propagation, impact characterization of armor materials, human cadaver and animal impact experiments, and surrogate thorax text fixtures.

PHASE I: Develop the overall design, including proof-of-concept for robust, accurate and reliable mechanical characterization of biological soft tissues and a methodology for incorporation of tissue and organ damage data into a general predictive model.

PHASE II: Develop and demonstrate a fully functional predictive injury model under realistic virtual testing environments. Conduct predictive testing to prove feasibility versus existing human cadaver tests over a range of loading conditions. Using this model, develop a prototype lightweight body armor design capable of providing optimal protection to the cardiovascular and respiratory systems of the human thorax against typical fragmentation and NIJ level III-A+ threats. Provide an injury assessment analysis of this prototype design versus current solutions (e.g., kevlar vests, modular kevlar/ceramic plate systems, Land Warrior, etc.).

PHASE III DUAL USE APPLICATIONS: This predictive tool could be used in a broad range of military and law enforcement applications to accurately predict injuries for various protective and threat scenarios. Further, the model would be directly applicable to the design new articles for body armor that are designed to minimize human injury.

REFERENCES:

U.S. Department of Justice, National Institute of Justice Standard 0101.04, Ballistic Resistance of Police Body Armor, Washington, DC, September 2000.

Bir, C.A. 2000, “The Evaluation of Blunt Ballistic Impacts of Human Thorax,” Ph.D. Dissertation, Biomedical Engineering Department, Wayne State University.

Wang, H-C K. 1995, “Development Of A Side Impact Finite Element Human Thoracic Model” Ph.D. Dissertation, Mechanical Engineering Department, Wayne State University.

Chen, W., Lu, F. and Zhou, B., 2000, "A quartz crystal imbedded split Hopkinson bar for soft materials," Experimental Mechanics, Vol. 40, No. 1, pp. 1-6.

KEYWORDS: Blunt trauma, predictive injury model, body armor

ARMY02-T012 TITLE: <u>A Fluorescent Liposome Detection Method for Detection of Biological Warfare Agent Toxins in Water</u>

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To develop a one-step rapid assay for the detection/monitoring of toxins in aqueous solutions using fluorescent polymerized liposome solutions that can be used with a portable fluorescent reader.

DESCRIPTION: Biologically-based toxins (e.g. ricin, botulinum toxin) are potential potent biological warfare agents. This effort focuses on taking advantage of recent lipsome-based detection methods for the development of an assay for rapid detection of these agents in water upon the occurrence of a biological attack. The aqueous samples may come from direct environmental sources (i.e. rivers) or consist of toxins trapped from air in water. ELISA assays using coated plates and fluorescent, luminescent or colorimetric visualization, have been developed for detection of proteins, however, they require multiple reagent addition, incubation and wash steps, and hence are not appropriate for a quick simple test that can be performed by unskilled personnel. Polymerized liposomes with simple sugar ligands incorporated have been used in colorimetric assays for influenza virus1 and cholera toxin B subunit2. The vesicle structure provides a bio-mimetic environment that promotes biological interactions. Use of polymerized liposomes increases the stability of the liposome materials to storage and assay conditions. The liposome based colorimetric assays are simple, requiring only the addition of the test sample to the liposomes followed by reading the absorbance, while ordinary colorimetric methods lack the sensitivity needed.

Of interest to this program is an assay that uses polymerized liposomes, incorporating antibody ligands, which became fluorescent upon binding of toxins. The polymerized liposomes would combine the stability of fluorescent liposomes with the sensitivity of fluorescent detection and the selectivity of antibody-antigen interactions.

PHASE I: The goal of the phase I research should be the development of fluorescent polymerized liposomes with antibodies incorporated for the detection of a model toxin system demonstrating proof of concept. Ideally there should be multiple versions of the assay: a general version that will detect a range of target toxins, and specific assays for each target. In the final form, arrays of liposomes will be presented to the sample for multiple target detection and fingerprint identification of targets.

PHASE II: Using the model methods developed in Phase I prepare different liposomes for the detection of multiple biologically-based toxins. Test the liposomes formulations individually and as mixtures against each target and against target mixtures. Determine optimal testing conditions (pH, temperature, sample/liposome ratio), and the functional range of the assay materials. Characterize detection limits, response time, reproducibility, and signal variation with variation in target mixtures. Develop arrays of liposomes for use in fingerprint detection of targets, and a portable fluorescent reader for reading the arrays. Develop an integrated approach to sample handling and assaying.

PHASE III DUAL-USE COMMERCIALIZATION: Phase III includes further refinement of the integration of the liposome assay materials and the fluorescent reader. Homeland defense and military applications include medical diagnostics of pathogens and disease as well as non-medical contamination avoidance sensors for biological warfare agents. The proposed liposome assays could be easily adapted to targets of interest to the medical community and used in conjunction with the portable reader for diagnostics in clinical or hospital settings.

REFERENCES:
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2. Charych D., Reicert A., Kuziemko G., Stroh M., Nagy J., Spevak W., Chem. Biol., 1996, 3, 113.

KEYWORDS: Biological warfare agents, liposomes, fluorescent polymers, antibodies, biosensors

ARMY02-T013 TITLE: <u>Field-Enhanced Carbon Monoxide Tolerance of Polymer Electrolyte Membrane (PEM) Fuel Cells</u>

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: Project Manager – Soldier Systems

OBJECTIVE: Develop a reformate-fed hydrogen/air polymer electrolyte membrane (PEM) fuel cell (FC) that exceeds state-of-art performance through field-enhanced electrocatalysis effected by chemically-inert magnetic microparticles incorporated within the catalyst layer of a FC membrane electrode assembly (MEA). Although not a focus of this solicitation, a long-term objective is to develop a 10-50 We/1kWh reformate-fed FC power system for the dismounted soldier.

DESCRIPTION: The Army, and particularly the Dismounted Soldier, has need for high-energy density, lightweight power sources that can be used to drive sensor, computational, and communication equipment, among others. Polymer electrolyte membrane FCs are candidates to fill these needs. The hydrogen-air fuel cell based upon perfluorosulfonated ionomer membranes (e.g., Nafion;) is a potential technology but the hydrogen source remains problematical. Reformate hydrogen produced by processing a liquid hydrocarbon is a possible source, but carbon monoxide (CO) is an undesirable co-product from the reformation reactor in the fuel-processing reactor sequence. The additional processing required to reduce CO to acceptable levels (~10 ppm or lower) adds complexity, weight, and volume to the fuel processor and, hence, the overall power system. Improved CO tolerance of the anode would attenuate these effects. In this regard, it has recently been reported (ref. 1, and citations therein) that field-enhanced electrocatalysis is effected at the hydrogen and air electrodes in PEM FCs through use of magnetic microparticles incorporated within the electrode-catalyst layer. The phenomena was demonstrated with neat hydrogen, and it remains uncertain what improvement may be effected with CO-containing reformate hydrogen that is oxidized on Pt or Pt-based electrocatalysts.

PHASE I: Demonstrate the feasibility of using chemically inert magnetic microparticles in single cell membrane-electrode assemblies and quantitatively characterize the effect of the particles on CO tolerance of the MEA. Both Pt and Pt/Ru electrode materials must be evaluated.

PHASE II: Identify and discuss unique and critical MEA-formulation and FC-operation conditions that are associated with the presence of magnetic microparticles in the MEA structure. Present a plan to address these issues and incorporate magnetic microparticles in a prototype field-enhanced hydrogen-reformate/air FC. Demonstrate field-enhanced electrocatalysis in a prototype 10-50 W air-breathing PEM FC running on (synthetic) reformate.

PHASE III DUAL USE APPLICATIONS: Improved reformate-fed PEM FCs would have impact upon a wide range of commercial needs, in additional to compact and nonportable military applications, including natural-gas fed residential or industrial applications.

REFERENCES:
1. J. Leddy and H. Chung, Proceedings of the 39th Power Sources Conference, 144-147 (2000).

KEYWORDS: Fuel cell, polymer electrolyte membrane, electrocatalysis, magnetic effects

ARMY02-T014 TITLE: Detection of Liquids on Surfaces using Long Wave Infrared Hyperspectral Imaging Spectroradiometer

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To build a lightweight wide area passive standoff imaging detection system capable of rapidly detecting liquids on surfaces for the purpose of contamination avoidance, and reconnaissance. To design, build and field-test a long-wave infrared hyperspectral imaging spectroradiometer for wide area detection of persistent chemical agents on the ground. To provide soldiers-in-the-field with the ability to quickly monitor large areas of a potential battlefield for liquid contaminants on the ground.

DESCRIPTION: Contamination avoidance requires the ability of U.S forces to monitor large areas of a potential battlefield for (chemical warfare) CW agents. The proposed system will allow rapid evaluation of large areas for CW contamination and provide detailed information as to position of ground contaminated with a persistent liquid. This system will also be capable of being mounted on a vehicle for real time contamination avoidance, providing a significant force multiplier in the event of a CW attack. CB agents certainly present a serious threat both to the civilian and military sectors and an adequate defense against these weapons will require rapid detection and identification of both known and unknown agents.

Recent measurements suggest that passive long wave infrared sensors such as the Joint Service Lightweight Chemical Agent Detector (JSLCAD) are capable of detecting liquids on the ground by utilizing cold sky reflectance. It has been shown that the sensitivity of this method can be enhanced by utilizing an imaging version of a passive sensor operating in the long wave infrared region. In the past decade, long-wave infrared imaging spectroradiometers have become available for numerous commercial applications such as surveying for minerals, detection of natural gas leaks, and pollution monitoring. There is a critical need in the Chemical and Biological community for a small, lightweight, inexpensive hyperspectral imaging spectroradiometer for battlefield use.

PHASE I:. Conduct a feasibility study of detecting liquid contaminants on the ground using a passive long wave infrared hyperspectral imaging spectroradiometer. Develop models for cold sky reflectance onto a contaminated surface and determine the expected differential radiance when a contaminant, such as SF96 is placed on a variety of surfaces such as painted metal, concrete, grass, and dirt. (SF96 has been shown to be a good simulant for long wave infrared surface contamination studies. SF96 is a silicone oil based simulant that can be obtained commercially from GE Silicones.) Using models for hyperspectral imaging sensor operating in the long wave infrared region, determine the expected sensitivity of a hyperspectral imaging spectroradiometer in terms of grams of contaminant per square meter of ground.

PHASE II: Develop and build a breadboard hyperspectral imaging spectroradiometer operating in the 8 to 12 micron region of the electromagnetic spectrum specifically designed for detecting contaminants on surfaces. The resolution should be approximately 10 wavenumbers. The system should be capable of extracting at least 30 contiguous bands in the in the long wave infrared region. The system should have a focal-plane-array and be capable of true imaging. Take detailed measurements of a variety of surfaces (sand, grass, painted metal, concrete, etc) contaminated with a small amount of SF96, a silicone oil based simulant, using an imaging spectroradiometer operating in the 8 to 12 micron region of the electromagnetic spectrum. Determine the sensitivity of such measurments

PHASE III DUAL USE COMMERCIALIZATION: In the past decade, long-wave infrared imaging spectroradiometers have been demonstrated to be useful for numerous commercial applications such as surveying for minerals, detection of natural gas leaks, and pollution monitoring. It is expected that such commercialization will accelerate once the sensors become less expensive and easier to use. It is one of the goals of this effort to produce affordable passive sensors that can be mass-produced for the battlefield.

REFERENCES:

1. W.R. Loerop, "Feasibility Of Detecting Chemical Agents Using a Chemical Imaging Interferometer From Low and High Altitude Platforms". U.S. Army Edgewood Research Development and Engineering Technical Report, ERDEC-TR-381, (1996)

2. J-M. Theriault, C. Bradette, and L . Moreau. " Passive Remote Monitoring of Chemical Vapors with a Fourier Transform Infrared Spectrometer" SPIE Vol 4087 - Application of Photonic Technology 4, R.A. Lessard and G.A. Lamprpoulos Editors (2000)

3. C.M. Gittins, M.F. Hinds, W.G. Lawrence, P.A. Mulhall, and W.J. Marinelli, "Remote Sensing and Selective Detection of Chemical Vapor Plumes by LWIR Imaging Fabry-Perot Spectrometry," (in press) Proceedings of the International Symposium on Spectral Sensing Research 2001, June 2001, Quebec City, Canada.

KEY WORDS: Long wave infrared sensor, liquid agent detection, passive remote sensing, reflectance spectroscopy.

ARMY02-T015 TITLE: Standoff Chemical/Biological Sensor Detection Algorithms

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: PM Artemis

OBJECTIVE: Develop innovative, integrated algorithms for laser–based chemical and biological agent standoff detectors in order to determine minimum detectable agent concentrations under various atmospheric, target, and platform conditions, with a focus on aerosol detection and changing backgrounds. Validate with existing field test data and accumulation of additional selected data sets.

DESCRIPTION: Innovative and creative approaches to this research and development effort are requested to establish and validate algorithms for aerosol detection and on-the-move detection. This effort directly supports both short-range and long-range goals for Contamination Avoidance, specifically in the Artemis, Wide Spectral Range Detection System, Joint Surface Contamination Detector, Joint Service Wide Area Detector, and Joint Decon Visualization System programs. This effort also supports 3 ongoing Small Business Innovative Research (SBIR) Phase II efforts.

Significant flexibility is allowed in formulating proposed approaches to meet these goals. A number of laser standoff sensors have been tested in the field and the results have been reported in the literature. These studies have usually included measurements of signal standard deviation for a variety of targets and under varying atmospheric conditions. Detection algorithms have typically made use of the simple, two-wavelength differential lidar formalism for vapor (not aerosols) and in a static configuratioin. Also, due to the variety of conditions, variations in the equipment used, and the different experimental methods of the investigators, it has not been possible to reliably correlate the results so as to develop an integrated algorithm. The recent development of new, robust detection algorithms adds to this confusion.

There are two methods of detecting aerosolized agents using a lidar sensor. The first approach is to bounce the light off a topographic target and measure the extinction. The second approach is to bounce the light off the aerosol of interest and measure the backscatter. The best approach depends on the size of the particles and the wavelength being used. If the particles are smaller than half the wavelength then extinction is the preferred approach, if the particles are larger than the wavelength then backscatter is better. In the case of chemical agent detection with an infrared lidar, the liquid rain particles are expected to be larger than the wavelength and the aerosolized agents are expected to have particles that are smaller than the wavelength. For this reason, an integrated algorithmic approach is needed. In addition, the characteristic spectral extinction and backscatter features of aerosols depend upon the particle size distribution. Therefore, the algorithm must account for this uncertainty in the spectral shape. While aerosol extinction and backscatter are generally well understood phenomena, relatively little work has been done in characterizing the specific extinction and backscatter coefficients for liquid agent rain or aerosolized agents. However, the models that predict the optical properties of aerosols exist and can be used to obtain reasonable estimates of the coefficients of interest. The traditional approach to aerosol detection, Differential Scattering (DISC), is limited in several critical ways; first it assumes that only two wavelengths are used, and current sensors are capable of using many wavelengths. Second, it assumes that there is only one aerosol present and does not allow for interference rejection which, of course, is critical in a battlefield application. Third, it assumes that the atmospheric attenuation is temporally stable. Fourth, it does not account for the uncertainty in the spectral features due to the changing and unknown particle size distribution.

The traditional approach for chemical vapor detection with LIDAR is Differential Absorption LIDAR (DIAL). This approach is limited for on-the-move detection in several critical ways; first it assumes that only two wavelengths are used, and current sensors are capable of using many wavelengths. Second, it assumes that there is only one vapor present and does not allow for interference rejection which, of course, is critical in a battlefield application. Third, it assumes that the atmospheric attenuation and the target backscatter are temporally stable which, of course, is not a valid assumption if one is scanning across a natural terrain background (such as trees or the ground if in a flight or other on-the-move scenario). These limitations demand a solution if LIDAR sensors are going to be used on the battlefield or in any realistic application. There are several differences in the spectral signature of the natural background and the absorptivity of chemical agents that can be used to address this problem. Although the spectral background is generally either unknown or only known approximately, spectra for chemical agents are well known. This information provides the basis for a matched-filtering type of processing, for example. Natural terrain reflectances tend to fall into classes with roughly similar spectral shape. This suggests that prior measurements could be used to form a library of spectral signatures for use in a Bayesian classifier approach, for example. In a continuously updated or push-broom mode of data collection, the natural background is expected to change relatively slowly until anomalies appear, such as boundary crossings. This offers the potential for temporally updating a statistical model for reflectivity, predicting the next measurement with the current model, and looking for significant breaks in the expected structure. Those breaks would indicate either the transition to a new background model, or the appearance of some other spectral feature such as a chemical of interest.

What is needed is a simplified and perhaps universal, integrated vapor / aerosol algorithm capable of realistic, on-the-move detection in changing backgrounds that can be used to interpret field data in terms of the most important factors that contribute to sensor sensitivity. These factors include short and long term sensor noise in both the transmit and receive channels, atmospheric propagation effects, target albedo, speckle, and background radiation. New sensor types to be fielded shortly will add other variables that must be evaluated for their impact on sensor performance. For example, the Warning and Identification Lidar Detector for Countering Agent Threats (WILDCAT) sensor1 will introduce the effects of very long range detection that will place special requirements on pointing stability. Such sensors will also be more susceptible to atmospheric effects than much shorter range systems that have been tested in the past. Manportable sensors2 based on Optical Parametric Oscillation (OPO) shifted solid state lasers will introduce issues related to the bandwidth of the output in the 8-12 m band and its effect on identifying gaseous agents in mixtures with overlapping absorption spectra. It will also be necessary to quantify the effect of pointing jitter on sensor sensitivity for manportable sensors and this may dictate the repetition rate of such systems. Finally, new detection and identification algorithms have been developed3 and the requirements they impose on sensor operation must be assessed. System and phenomenology issues such as these must be taken into consideration in the course of developing the objective algorithm.

The results of this effort will be applied in the near-term to the Artemis acquisition program to enhance its CB detection capabilities on the multiple platforms for which it is being developed.

PHASE I: All efforts are to be directed toward identifying an integrated vapor / aerosol, on-the-move algorithm development strategy and a viable test matrix. Identifying all existing field test data and assessing the current state-of-the-art of algorithms relevant to laser-based standoff chemical and biological agent detection will establish a baseline. Available sensors will be evaluated for the purpose of gathering additional field data where gaps exist.

PHASE II: Phase II will consist of employing the Phase I strategy to develop an integrated vapor / aerosol, on-the-move algorithm and validate it with field data. Additional field data will be obtained as needed to establish the effect of sensor and test conditions that are critical to algorithm performance and hence sensor sensitivity. Sensor sensitivity will be tested with advanced algorithms.

PHASE III DUAL-USE APPLICATIONS: Phase III military applications include optimized full-sized and miniature standoff CB detectors for contamination avoidance and decontamination. In addition, dual-use intelligence and homeland defense applications could directly benefit from having a standoff detection device with optimized performance. Phase III commercial applications include spin-off detectors for standoff environmental pollution monitoring and for drug interdiction.

OPERATING AND SUPPORT (O&S) COST REDUCTION (OSCR): Optimized sensors will be more reliable and will have a faster response time. Faster sensor response times will give instantaneous results regarding the presence of CB agents which will reduce O&S and manpower costs associated with waiting for minutes or hours for delayed results. The availability of instantaneous results will also reduce the manpower and time required to perform inspections of potentially contaminated areas or materiel. For example, the optimized detector could allow inspections of 50 or more items of potentially contaminated materiel in the time it takes the current system to inspect one item.

REFERENCES: 1. “WILDCAT chemical sensor development,” D. Cohn, C. Swim, and J. Fox, Proceedings of the SPIE 15th Annual International Symposium on Aerospace/Defense Sensing, Simulation, and Controls, April 2001. 2. D. Cohn, J. Fukumoto, J. Fox, and C. Swim, “Compact DIAL sensor: SHREWD”, Proceedings of the SPIE 15th Annual International Symposium on Aerospace/Defense Sensing, Simulation, and Controls, April 2001. 3. “Extended Kalman filter for

multiwavelength differential absorption lidar", R. Warren and R. Vanderbeek, Proceedings of the SPIE 15th Annual International Symposium on Aerospace/Defense Sensing, Simulation, and Controls, April 2001.

KEYWORDS: algorithms, biological, chemical, detection, LIDAR, standoff, sensitivity.

ARMY02-T016 TITLE: Rapid Quantitative Method for Determining Biological Decontamination Efficacy

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Provide a rapid, automated means of determining the efficacy of liquid decontaminants on bacterial spores, vegetative cells, and toxins.

DESCRIPTION: The plate count method has been traditionally used to determine the effectiveness of antimicrobial agents in decon efficacy testing. This method requires large amounts of microbiological growth media and up to several days to complete. Likewise, assays for biological toxins require cumbersome tissue culture assays that require even more material and time to complete. This effort will develop a platform and assay for determining the efficacy of liquid decontaminants on bacterial spores, vegetative cells, and toxins. The assay will be able to quantify the amount of viable organisms or toxin remaining after treatment with a liquid decontaminant and determine the kinetics associated with the destruction.

PHASE I: Demonstrate the feasibility of measuring a factor associated with eukaryotic and prokaryotic cellular metabolism (e.g. cellular respiration) occurring in in vitro samples and accurately correlating it to the amount of cell growth/death occurring in the sample.

PHASE II: Demonstrate an analytical platform and assay capable of quickly and accurately determining cell growth/death as indicated in Phase I. The instrument must have a high throughput and be capable of handling multiple samples at the same time.

PHASE III DUAL USE APPLICATIONS: Hardware and assays developed could be used in the pharmaceutical industry for developing antibiotics and other antimicrobials. The toxin assays would provide a rapid means of determining toxicity of a variety of compounds.

REFERENCE: Pitner, J.B., M.R. Timmins, M. Kashdan, M. Nagar, D.T. Stitt, 1999. High-Throughput Assay System for the Discovery of Anti-Bacterial Drugs. Abstracts from the National Meeting of the American Association of Pharmaceutical Scientists, New Orleans, LA

KEYWORDS: Decontamination efficacy testing, bacterial spore, toxin assays

ARMY02-T017 TITLE: Telemedicine and Advanced Medical Technology – Refined Training Tools for Medical Readiness

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: Medical

Objective: To develop and apply new tools to evaluate and report the effectiveness of simulators and simulation systems in training medical personnel in key combat casualty care skills through the exploiting and/or modifying systems in use in military aviation and aerospace industries.

Description: Joint Vision 2010 and its concomitant healthcare doctrine Force Health Protection, clearly identifies the need to enhance the quality of combat casualty care in future conflict A very considerable gap exists between what currently medical skills can currently be taught in peace and what are required for conflict. A simple gap analysis shows that the only feasible method of training in these skills is the use of simulation. A considerable array of medical simulators is already appearing on the market. More are being developed both in the commercial world and under the aegis of DOD and other federal agencies. They are gradually being introduced for medical skills training both in the military and nationally. There currently exists no technology to enable institutions and organizations currently using simulators for medical training, to measure or even prove the effectiveness of simulation or individual technologies. In the absence of such tools it will be impossible to judge which medical simulators have application or value in the training of combat casualty care skills and for that matter, any other medical skills application. These tools will establish that, as in aviation, simulation training 1) provides a positive transfer of training related to performance of actual casualty care, 2) eliminates risk to human and animal patients, 3) reduces cost of training by providing readily available, realistic replications of combat casualty care and, 4) is positively received by trainees and managers. Evaluation methodology should be applied to measures of effectiveness for four categories of medical simulation. This requires providing effective, realistic replication of combat injuries in battlefield conditions. Simulator training involving desktop clinical software, part-task trainers, medical simulation systems and virtual reality applications should enhance combat casualty care skills for deploying and deployed forces. Verification and validation of simulation training of combat casualty care provides the deploying medical force with more effective and less costly training tools for employment by medical assets from far forward care to the operating room.

These evaluation and reporting tools should be applied to performance metrics (measures of effectiveness) for all categories of medical simulation. Comparative studies should be conducted to demonstrate effectiveness of tools to assess training efficacy.

PHASE I: Describe the concept and development plan for new assessment tools for medical training simulators / systems through a comprehensive evaluation methodology. Establish comparative studies to validate simulation training by demonstrating and reporting the extent of transfer of training from simulators / systems to actual medical care. Demonstrate the concept by applying the developed verification and validation tool(s) to at least one medical simulation system.

PHASE II. Develop system(s) to apply tools developed to each of four categories of simulation; CD-ROM multimedia, mannequin-based, part-task trainers, and virtual reality based simulators.

PHASE III. DUAL USE COMMERCIALIZATION: Develop plan to commercialize developed tools and make available to military and civilian trainers. Results of these evaluations will lead to rapid product development leads to prompt shelf availability of medical simulators.

REFERENCES. “Operational Capability Elements; Joint Medical Readiness”, Page 6 (section 3.2.1), Joint Science and Technology Plan for Telemedicine (1997).

KEY WORDS: Medical modeling and simulation, medical skills training, individual and unit training, evaluation methodology, medical force readiness.

ARMY02-T018 TITLE: Systems For Alternate Sources Of Thrombin And Fibrinogen For Human Use

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Medical

OBJECTIVE: Development of Alternate Sources of Thrombin and Fibrinogen for Human Use

DESCRIPTION: 50% of Killed In Action's and 25% of Died Of Wound's die from uncontrolled hemorrhage. These statistics have not changed for over 100 years. Recent developments have suggested that a fibrinogen based hemostatic bandage can reduce blood loss in severe traumatic and life-threatening hemorrhage and can improve survival. Presently, the cost of fibrinogen makes these bandages extremely expensive and precludes wide spread use and easy replacement as envisioned for local hemostatic agents in combat. The low yield of fibrinogen via present methods (Cohn fractionation) drives the cost. A less expensive source of fibrinogen and thrombin would reduce the cost of these materials and make field use of a fibrinogen-based local hemostatic agent feasible. Thrombin and fibrinogen from an alternate animal source would also reduce concerns of contamination with blood borne pathogens, particularly the transmissible spongiform encephalopathies for which there are neither a screening test nor treatment.

PHASE I: Purification of thrombin and fibrinogen from animal source (non-human, non-primate, non-domestic). Characterization of thrombin and fibrinogen from animal source. Define optimal storage conditions for thrombin and fibrinogen from animal source.

PHASE II: Demonstrate chemical and functional equivalence of human and animal-derived thrombin and fibrinogen. Demonstrate level of immunogenicity of animal-derived thrombin and fibrinogen. Develop lyophilization strategy for thrombin and fibrinogen from alternate animal source. Demonstrate longevity of thrombin and fibrinogen from animal source through long-term storage studies. Introduce thrombin and fibrinogen from animal source into present formulations of thrombin/fibrinogen-based local adhesive bandages. Perform or participate in preclinical testing of thrombin and fibrinogen from animal source to include in vitro testing of clot strength and standard clotting tests. Perform or participate in 1) preclinical testing of the thrombin/fibrinogen-based local adhesive bandage to include in vivo testing using existing animal models and 2) clinical testing. Candidate products must be tested against the hemostatic bandages consisting of human-derived thrombin and fibrinogen.

PHASE III DUAL USE APPLICATIONS: Define a large-scale process for developing thrombin and fibrinogen from animal source. Produce and support alternate animal source of thrombin and fibrinogen during introduction into clinical use.

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KEYWORDS: hemostasis trauma adhesive bandage fibrinogen animal (non-human, non-primate, thrombin non-domestic)

ARMY02-T019 TITLE: Statistical Tool for Analyzing Binomial and Multinomial Longitudinal Data

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Medical

OBJECTIVE: Develop a statistical tool in the language R that will allow a user to analyze longitudinal data where the outcome variable is binomial or multinomial.

DESCRIPTION: Many performance and health variables of interest to commanders, policy makers and researchers are dichotomous or multinomial in nature. For instance, retention, depression and some forms of performance are dichotomous – a soldier stays or leaves active duty; is or is not depressed; and succeeds or fails on a specific task. Other outcomes are multinomial. For instance, performance ratings often fall into top-third, middle-third and bottom-third categories. In terms of Future Combat Systems (FCS), it is important to analyze binomial and multinomial outcomes over time to model how changes in force structure impact soldier retention, health and performance.

Statistical tools for analyzing binomial and multinomial data are well-developed (e.g., McCullagh & Nelder, 1989); however, these tools are applicable primarily for data that is non-longitudinal in nature. When binomial and multinomial data is collected from the same individual over time or multiple individuals nested within groups, the Generalized Linear Models or GLMs described by McCullagh and Nelder are severely limited. In recent years, important advances have been made in statistical theory in terms of modeling longitudinal data. One of these advances is the development of the Nonlinear and Linear Mixed Effects (NLME) tool for the open-source language R and the commercial counterpart S-PLUS (Pinheiro & Bates, 2000). NLME is well-suited to modeling Army data because the tool is designed to efficiently handle multiple levels of nesting (soldiers over time, nested within Squads, within Platoons, etc.). NLME has been used extensively for Army health and performance research (e.g., Bliese & Castro, 2000; Bliese & Britt, 2001; Jex & Bliese, 1999; Jex et al., 2001; Thomas et al., 2001). One shortcoming of NLME, however, is that it is not able to handle dichotomous or multinomial data. Thus, there is a need to develop a statistical tool in R that allows the user to efficiently model longitudinal binomial and multinomial variables with multiple nested layers.

PHASE I: This phase would involve providing: (1) a draft of a document detailing a statistical solution to the problems associated with analyzing longitudinal binomial and multinomial data, and (2) analysis of statistical tool variations implemented in R based on the statistical solution. The statistical tool would be required to analyze dichotomous variables from 300 respondents over four periods of time and return verifiably correct estimates of the statistical parameters.

PHASE II: This phase would involve (1) Development of a statistical tool prototype based upon phase I analysis, (2) verification of the statistical solution and (3) development, refinement and testing of the statistical tool. Verification of the statistical solution would involve publishing a manuscript explaining the solution in a peer-reviewed statistical journal. This will ensure that independent statisticians confirm the utility of the proposed solution. Development, refinement and testing of the statistical tool will include maximizing the tool's efficiency, completing thorough documentation and running simulations detailing the tool's robustness. Simulations must include analysis of the tool's performance with different patterns of missing data.

PHASE III DUAL USE APPLICATIONS: The development of a statistical solution to the problems associated with the analysis of binomial and multinomial longitudinal data will have broad value across the military and industry. This is because many organizations collect and attempt to model binomial and multinomial data. In addition, the development of a statistical tool implemented in the open-source language R will make the tool available to members of academia, industry and the military.

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KEYWORDS: Statistical tool, binomial, multinomial longitudinal data